Geophysical Research Abstracts
Vol. 13, EGU2011-6359, 2011
EGU General Assembly 2011

Numerical modelling of magma transport in dykes

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The rheology and the dynamics of an ascending pure melt have been studied in detail. The presence of a carried crystalline load modifies the bulk properties of the fluid (i.e. increasing the effective viscosity and density) and consequently the behaviour of the system is also altered. Indeed, the higher density and viscosity of such crystalline flows causes a decrease of the ascent velocity and modifies the shape of the velocity profile, from the typical Poiseuille flow, to a Bingham-type flow. Observation of textures in frozen dykes generally show that crystals transported by the melt phase are preferentially oriented parallel to the conduit edges. Such a structural arrangement is often interpreted as a consequence of the magma flow. Crystal rotation and/or their migration toward the centre of the dyke (due to the so-called Bagnold effect) are typically proposed mechanisms to explain such textural observations. However, the mechanisms that are active during magma ascent are not still well quantified. Particularly, the possibility for crystals to be segregated from a viscous granitic melt phase during magma ascent has never been investigated, let along the implications that this process could have on magmatic differentiation. Here, we use a simple mechanical model, which we thoroughly verify by reproducing different analytical solutions for rigid inclusion/fluid interactions, to study the behaviour and the dynamics of crystals-bearing melt ascending in a dyke. Results show that crystals initially randomly oriented before entering the dyke modify the magma velocity and tend to become aligned with the flow direction. Moreover, some experiments showed that the melt phase can effectively be squeezed out from a crystal-rich magma while subject to a given pressure gradient range. This demonstrates that crystal-melt segregation in dykes during granitic magma ascent is a viable mechanism and has to be considered as a viable mechanism for magmatic differentiation.